Connecting the silos: Implementations and perceptions of linked data across European libraries

Abstract

Purpose – To determine how information professionals in Scotland and in European national libraries perceive linked data as well as if and how they are implementing it.

Design/methodology/approach – The authors applied four data collection techniques: a literature review, semi-structured interviews (n=15), online resources analysis (n=26), and an online survey (n=113). They used constant comparative analysis to identify perceived benefits and challenges of linked data implementation, reasons behind adoption or non-adoption of linked data and the issues hindering its implementation in libraries.

Findings – Some projects demonstrate linked data's potential to augment the visibility and discoverability of library data, alongside with overcoming linguistic barriers, and supporting interoperability. However, a strong need remains to demonstrate the Semantic Web's potential within libraries. Participants identified lack of expertise and lack of resources/time/staff as implementation barriers. Several other issues remain unsolved, such as licensing constraints, as well as difficulties with obtaining management buy-in for linked data initiatives, even where open data is government-mandated.

Practical implications – Information professionals and vendors should collaborate to develop tools for implementation. Advocacy through disseminating and reviewing successful implementations can help to solve practical difficulties and to obtain management buy-in.

Originality/value - This is the first known study to present a multinational, comprehensive picture of library linked data implementations and associated librarians' perceptions of linked data.

Keywords – Semantic Web, Linked data, Linked Open Data, Library data, Metadata standards, National libraries, Scottish libraries, Europe, Cultural heritage, W3C.

Paper type - Research paper

Introduction

The digital realm evolves consistently, presenting information professionals with the need to update their professional skills constantly. Web 3.0 is no exception. In 2001, Sir Tim Berners-Lee introduced an extension to the World Wide Web called the Semantic Web (SW) which would enable relationships not only between documents, but also amongst the elements (data) within documents. Also known as Web 3.0 or the Web of Data (Tallerås, 2013; van Hoolan and Verborgh, 2014), linked data (LD) is the accepted means to enable the SW (Bizer *et al*., 2009). The goal is to provide a seamless 'web of trust' where anyone can make contributions (Library of Congress, 2012a). This requires communicating the content in a format 'understandable' by computers, so they can automatically build relationships between resources to enrich user experience and improve discoverability (Rasmussen Pennington, 2016).

The trend toward opening data is spreading across sectors, including government, industry and cultural institutions (Shiri and Davoodi, 2016), with different benefits for each environment. For libraries and cultural institutions, it provides improved information services. For industry, automatic data provides commercial benefits. For research, it reduces work duplication and therefore supports societal progress. For government, it provides transparency and benefits the country's economic potential (Stuart, 2011). Open government data has become a worldwide trend, with increasing resources invested in making it available to the public (Zhao and Fan, 2018). Despite this trend, most governmental agencies are facing severe obstacles in implementing LD, even when government policies require open government data publication, such as in Scotland (Scottish Government, 2015).

Within libraries and cultural institutions, Linked Open Data (LOD) allows cultural heritage objects to enter the Web of Data, but it requires transforming traditional metadata techniques in order to open collections to a wider audience (Jones and Seikel, 2016). Although LD's potential is recognized in this sector, professionals are uncertain about its benefits, and implementation faces several challenges.

This paper presents the status of LD adoption in European libraries through the convergence of two related studies: implementation across European national libraries (Cagnazzo, 2017) and awareness and use among Scottish libraries (Rasmussen Pennington, 2017). Based on these results, it makes recommendations for improving best practices in library LD implementation and suggests future research. This is the first known study to present a multinational comprehensive picture of library LD implementations and associated librarians' perceptions. Implementing the recommendations in this paper could change the direction of librarianship.

Whilst the national library study offers a broader view, the latter provides a targeted lens on one country. The choice for analysing European national libraries stemmed from the consideration of their role in preserving and widening access to all knowledge published within their own countries (Jøsevold, 2016). The specific mandate of national libraries varies among countries depending on size, history, development status, and culture (Wainwright, 1993). That said, national libraries are ultimately responsible for related to "building, preserving and enabling access to collections at a national level, and providing relevant services throughout a nation" (Breeding, 2011, p.21). Furthermore, national libraries can lead the development of technological standards for record formats, data exchange, and interoperability protocols, since they are usually situated under the government and therefore well-positioned for informing national policy (Hagerlid, 2011). Increasing interoperability within Europe is essential given the geographic and political intertwining of its nations. Evaluating Scotland as one nation residing within the European context allowed the authors to consider how and whether the country has the ability to effectively share resources among its own libraries. As a country rich in historically important cultural heritage, it should be able to share resources among its institutions. Historical and governmental data belongs to Scotland's citizens and are of interest worldwide; for these reasons, broadening access, findability, and discoverability is essential (Ruthven and Chowdhury, 2015).

Semantic Web and linked data

The SW was introduced to bring meaning and logic to the existing WWW (Berners-Lee *et al.*, 2001; Baker *et al.*, 2011). The first and most important step towards its realization is to publish data online in a machine-readable format (Berners-Lee, 2000). As previously mentioned, if SW is the goal, LD is the tool to achieve it (Bizer *et al.*, 2009). Several ways of describing the LD concept have been suggested. Berners-Lee, defined LD as "the Semantic Web done right" (Berners-Lee, 2008). According to Bizer *et al.* (2009), 'linked data' indicates a set of best practises for publishing and connecting structured data on the web (Bizer *et al.*, 2009). LD should be interpreted as a continuously evolving set of best practices for the publication of structured data on the web rather than a specific technology (Van Hoolan and Verborgh, 2014). Heath (2009) defines LD as "a means to dismantle data silos". Shiri and Davoodi (2016, p.65) define LD as a "set of standards, data publishing models and methods that bring consistency, interoperability and shareability to unorganized and unidentifiable data on the web."

Berners-Lee (2006) outlined the key requirements for LD to be classified as such in his 'Linked Data Principles':

- Use URIs as names for things
- Use HTTP URIs so that people can look up those names
- When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL)
- Include links to other URIs, so that users can discover more things

The first principle requires a unique identifier in the form of a Uniform Resource Identifier (URI) for each concept. Next, each URI must use HTTP for online access to disambiguated concepts (Van Hoolan and Verborgh, 2014). Thirdly, URIs must be associated with useful information presented through standards such as Resource Description Framework (RDF), a generic, graph-based data model that describes things in the form of statements called 'triples' (Bizer *et al.*, 2009; Tallerås, 2013). A triple consists of a URI-based subject, object and predicate. Predicates (or properties) describe the relationship between elements. The subject and object of a triple can belong to different datasets; this is how RDF links documents (Bizer *et al.*, 2009). Figure 1 illustrates an RDF triple. Finally, things must link to other things (Van Hoolan and Verborgh, 2014). To recapitulate, LD employs HTTP URIs to identify, HTTP to retrieve, and RDF to describe (Bizer *et al.*, 2009).

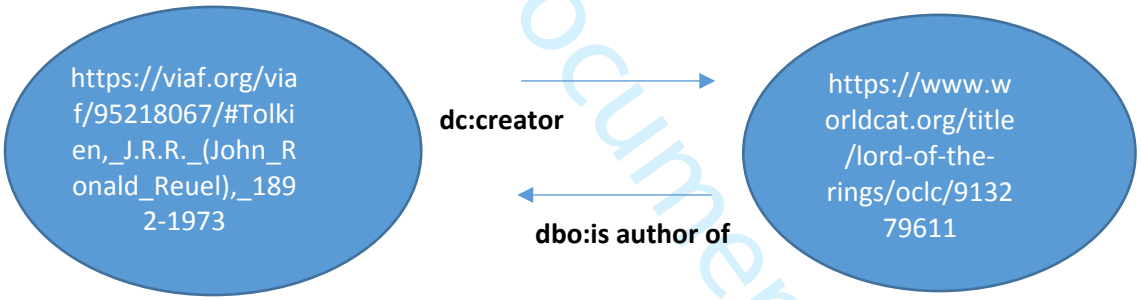

Figure 1: Graphical representation of an RDF triple. On the left is the URI of the Virtual International Authority File (VIAF) page for J.R.R. Tolkien; on the right is the URI of the page containing the bibliographic description of a printed version of Lord of the Rings on WorldCat. The two entities are connected by properties drawn from the Dublin Core and DBpedia ontologies.

Another main component of the SW is ontologies. They provide a shared understanding of a domain, gathering together its important notions (expressed in RDF), and establishing relationships between notions (Bizer *et al.*, 2009; Antoniou *et al.*, 2012). Commonly adopted ontology languages include Web Ontology Language (OWL), (OWL, 2013; Antoniou *et al.*, 2012), Simple Knowledge Organization System (SKOS), (SKOS, 2013), and Friend of a Friend (FOAF)/Description of a Project (DOAP) (Berners-Lee, 2006).

To evaluate LD applications, Berners-Lee (2006) developed the 'five-star scheme':

★ Available on the web (in whatever format) but with an open licence, to be Open Data

★★ Available as machine-readable structured data (e.g., .XLS instead of a scanned image of a table)

★★★ As above, plus non-proprietary format (e.g., .CSV instead of .XLS)

★★★★ All the above, plus use of open standards set by W3C (RDF and SPARQL) to identify things

★★★★★ All the above, plus linking your data to other people's data in order to provide context

A related SW standard established by the W3C (W3C, 2017) is SPARQL, a query language for RDF that allows data manipulation and retrieval of data in triple stores (SPARQL, 2017).

Linked data applications

Started in 2007 and supported by the W3C Semantic Web Education and Outreach Group, the Linking Open Data Project's goal was to identify existing datasets available under open licences, convert them into RDF, and publish them online, with links to other data sources (Bizer *et al.*, 2009). Contributors to DataHub, a free data management platform, collect and curate the metadata published in the LOD cloud, where organizations are encouraged to publish their data collections (Abele *et al.*, 2017; DataHub, n.d.). A central hub of LOD is DBpedia, generated from extracted structured Wikipedia data (DBpedia, 2017). It is a publicly accessible RDF dataset covering several domains (TED, 2009). In 2014, DBpedia consisted of 3 billion RDF triples; more recently, it reached 23 billion triples (Freudenberg, 2017).

Internet corporations quickly embraced LD. Google's Knowledge Graph aggregates data drawn from various sources and then provides it to the user in search results (Rasmussen Pennington, 2016). Results appear on the right side of the screen when searching for a popular topic or person. Google presents it as a tool to render faster, quicker, and more relevant searches thanks to LD's disambiguation ability and its capacity to 'understand' information in a way that is closer to human comprehension than traditional information retrieval systems (Singhal, 2012).

Facebook's Open Graph Protocol allows any web page to have the same functionality as any Facebook object (Open Graph Protocol, 2014). Built on RDFa, a W3C recommendation that adds a set of attribute-level extensions for encoding structured data within web documents, the Open

Graph Protocol enables site owners to determine how entities are described on the social network (Heath and Bizer, 2011; RDFa, 2017). It is the mechanism behind Facebook's "Like" button.

Governmental portals occupy a significant part of the LOD cloud. The USA (www.data.gov) and the UK (data.gov.uk) have made government data available under open licenses; links to Open Data portals worldwide can be found at www.dataportals.org. They represent the embodiment of the Open Government Partnership (OGP; www.opengovpartnership.org). 67 countries have joined this initiative to show their commitment to making data free to use, reuse and redistribute according to Open Data principles (Attard *et al.*, 2015). In order to provide guidance to governments interested in publishing their data, the Open Government Working Group suggested the Eight Open Government Data Principles (https://opengovdata.org/): complete, primary, timely, accessible, machine-processable, non-discriminatory, non-proprietary, and licence-free. The Scottish Government launched its Open Data Strategy in 2015, with the following definition: "non-personal and non-commercial data, which is accessible to anyone, via the internet, free of restriction on use and, according to most usages of the term, in a machine readable form" (www.gov.scot/Publications/2015/02/6614).

Open Government Data initiatives are based on three pillars of transparency; to fight corruption and improve accountability, citizen participation, and collaboration between public bodies and the general public for strengthening democracy (Attard *et al.*, 2015). Furthermore, since government agencies continuously generate datasets related to citizens' daily lives and incur significant taxpayer costs collecting this data, government data are public. They should therefore be available to the public from a legal perspective (Zhao and Fan, 2018). Janssen *et al.* (2011) grouped the advantages of publishing government data into three categories: political and social, economic, and operational/technical.

Publishing Open Government Data facilitates an innovation in the traditional relationship between public organizations and citizens: once data are made available, the public becomes an active part of data processing, and people are then enabled to enrich, combine, reuse, and even collect data. Opening data allows the formulation of additional views and therefore the elaboration of novel problem-solving strategies. It inspires new uses of data and it allows government to collect feedback from the public, which can provide valuable learning outcomes (Janssen *et al.*, 2011).

However, opening data does not automatically mean making data easily accessible and re-usable. It is essential that governments adopt standardized methods and the necessary technologies to present data in a user-friendly way. Furthermore, metadata are essential in order to enable discoverability and interpretation (Janssen *et al.*, 2011). Attard *et al.* (2015) argued that the

adoption of different data formats (e.g., .PDF, .CSV, .XLS) by public administrations represents a technical barrier to both data consumers and providers and it hinders government data transparency.

To assist public bodies releasing their data, the W3C eGov Interest Group has developed a set of steps for publishing government data which encourage the adoption of standards with the intent of facilitating public use: identify, document, link, preserve, expose interfaces, and create standard names/URIs for all government objects (Attard *et al.,* 2015). To realize goals such as economic growth, innovation and transparency, governments should embrace a culture in which opening data to the public is part of all working processes and, if there are no barriers (e.g., GDPR, confidentiality), data is automatically publicized (Zuiderwijk and Janssen, 2013).

Library data

The key to accessing library collections is metadata: it allows the description, identification, organization, retrieval, access, use, conservation, delivery and preservation of all resources (Sugimoto *et al.*, 2015). Van Hoolan and Verborgh (2014) describe metadata from cultural institutions as 'legacy metadata', since it lasts long-term.

Since metadata were created over the years by several agents and for various purposes, a high degree of heterogeneity in the description of the same entities often occurs, with a consequential lack of interoperability (Tallerås *et al.*, 2013; Sugimoto *et al.*, 2015). To overcome this issue, bibliographic standards exist to enable the exchange of library metadata across institutions (Tallerås, 2013), such as MARC, AACR, and RDA. Developed before the WWW, MARC is used to create human-readable records and machine-readable text strings, but as it allows limited actions, they are not particularly fit for digital resources (Tallerås, 2013). Also, MARC is based almost solely on the manifestation of an item (in FRBR terms), (Tallerås, 2013; Shiri and Davoodi, 2016), resulting in siloed records. RDA seeks to bring cataloguing closer to the SW principles. More adaptable than AACR, RDA supports the Functional Requirements for Bibliographic Records (FRBR) identified user tasks of finding, selecting, identifying and obtaining a wide range of resources (Shiri and Davoodi, 2016).

The advent of linked data in the bibliographic environment requires better structure from the FRBR-based bibliographic models to take advantage of the Semantic Web potential. FRBR-LRM (Library Reference Model) is considered one step in the evolution toward this future possibility (Strader, 2017). The result of the IFLA FRBR Review Group's analysis of FRBR, its goal was to create a single conceptual model that maintains the entity-relationship model, covers all aspects of the

bibliographic universe, and merges together FRBR, FRAD (Functional Requirements for Authority Data), and FRSAD (Functional Requirements for Subject Authority Data) (Riva, 2016). FRBR-LRM identifies five user tasks: Find, Identify, Select, Obtain and Explore, the latter being a new addition to the user tasks recognised in FRBR but employed in FRSAD (2010). The harmonisation of the three existing models into one caused a certain loss of granularity and diminished explanatory power; distinction among the three original models had reason to be granular, given the differences between authority and bibliographic data (Strader, 2017). Despite the potential improvement, LRM is still likely inadequate to handle metadata for all resource types; this is why it is perceived as a step in the evolution of library metadata, rather than the endpoint (Frederick, 2017).

The W3C's Library Linked Data Incubator Group sought to improve interoperability of WWW library data by promoting discussion and collaboration amongst librarians involved in LD projects (W3C Incubator Activity, 2010). It concluded that library data is not integrated within the web, it is often expressed in natural language, its standards only apply to the library community, and vendors rather than information professionals drive its technological development (Baker *et al.*, 2011).

LD offers libraries the means for enabling interoperability, improving data management and enhancing the amount and quality of information available to a larger audience (Byrne and Goddard, 2010). It can enhance discoverability, potentially helping libraries eventually appear within that first page of search engine results (Onaifo and Rasmussen, 2012). With LD, people lacking in knowledge of library jargon and metadata standards can benefit from the rich information stored in libraries' catalogues and other online resources (Rasmussen Pennington, 2016). The sector is approaching the end of cataloguing records containing siloed library-provided data, and moving towards enriched data coming from various resources. This requires library data to be structurally flexible and applicable to multiple online contexts (Coyle, 2009). Essentially, "We are moving from cataloguing to catalinking" (Wallis, 2013, slide 19).

Studies have been conducted to identify the benefits that the SW may provide to the library and cultural heritage environment. According to Marden *et al.* (2013), LOD can enable cultural heritage institutions to share their holdings with a wider audience, which changes the traditional relationship between holder, interpreter and consumer of knowledge. Linked open datasets can enrich user experience, empowering them to manipulate and attribute their own meaning to cultural heritage collections. Below are the advantages that Hallo *et al.* (2016) attribute to library LD:

- Improve data visibility
- Allow linkage to other online services

- Improve open data recovery
- Enable interoperability without affecting data source models
- Allow modelling things of interest related to a bibliographic resource such as people, places, events, and themes
- Improve the credibility of end users' semantically meaningful annotations

Enhancing data visibility and findability on the open web (OCLC, 2012), where most users now seek information, is a goal libraries should aim for in order to remain relevant (Onaifo and Rasmussen, 2012). Augmented visibility can to an increase in the use of library data, hence an increase of library users (McKenna, 2017).

LD supports multilingualism, since each entity is identified by a standard URI (Shiri and Davoodi, 2016). It allows libraries to create shareable, extensible and reusable data pools, saving cataloguing time and cost (Marden *et al.*, 2013; Ryan et al, 2015). In addition, it enables innovative library discovery systems, as well as creative web applications based on library resources (OCLC, 2012; Shiri and Davoodi, 2016). It offers tools for better data management, allowing users to store, share and reuse data as needed (Byrne and Goddard, 2010) and facilitates information retrieval by leading people to a web of related data with a single search (McKenna, 2017).

Converting data into informative datasets, institutions establish themselves as trusted sources of quality data (Marden *et al.*, 2013). Ultimately, LOD contributes to the path towards seamless and unified access to content of heterogeneous repositories, which is the aim of the SW (Shiri and Davoodi, 2016).

Linked data and libraries

In 2011, Library of Congress (LC) announced its intention to develop a new bibliographic framework based on LD principles and RDF (Library of Congress, 2011). The release of *Bibliographic Framework as a Web of Data: Linked Data Model and Supporting Services* (Library of Congress, 2012a) led to BIBFRAME, a dedicated LD model for bibliographic metadata (Tallerås, 2013). BIBFRAME aims to assist libraries with their transition from MARC21 to LD, ensuring data exchange continuity, which enables savings on cataloguing cost and resource sharing (Neish, 2015). The project requires a shift in thinking: rather than embedding data in a record, links are provided to external authoritative sources (Bartlett, 2013). BIBFRAME's *Library of Congress Linked Open Data Service* (http://id.loc.gov/) enables both humans and machines to access data values and hosted controlled vocabularies (Library of Congress, n.d.). The service allows access and bulk download of authority names and controlled vocabularies at no cost, and permits users to link their metadata

to the LC data values (Marden *et al.*, 2013). These initiatives have placed LC at the forefront of library LD implementation.

The Cornell University Library, the Harvard Library Innovation Lab and Stanford University Libraries have led library LD initiatives. *Linked Data for Libraries* (LD4L) (2014-2016) intended to facilitate the retrieval of scholarly information through the Scholarly Resource Semantic Information Store (SRSIS). SRSIS is both applicable within individual institutions and through a network of LOD resources to capture the value added by librarians, domain experts and scholars to information resources (LD4L, 2016). Another project is *Linked Data for Production* (LD4P) (2016-2018), in which said institutions, LC, Columbia University and Princeton University are piloting the production of library LD. It focuses on "developing standards, guidelines, and infrastructure to communally produce metadata as linked open data" (Branan and Futornick, 2017).

OCLC has been very active in LD implementation. Initiatives include the Virtual International Authority File (VIAF), which combines multiple name authority files into a single service in order to link widely-used authority files and make them available on the Web (VIAF, 2017). They have also released a LD version of the LCSH-derived Faceted Application of Subject Terminology (FAST); Dewey Web Services, which offers part of the DDC as LD; WorldCat as LD (OCLC, 2017).

Launched in 2008, Europeana is a well-known open-access digital library of cultural heritage information, bringing together millions of digital objects from European institutions (Ruthven and Chowdhury, 2015). Users can search across collections of libraries, museums, and archives, breaking open the typical institutional silos (Thorsen and Pattuelli, 2016).

Research questions and methodology

The research questions addressed were as follows:

1. What are librarians' understandings of the concepts "linked data" and "Semantic Web"?
2. What are the perceived benefits of library linked data implementation?
3. What are the reasons behind libraries' decisions to implement linked data?
4. What are the barriers to linked data adoption?
5. What are the challenges encountered by libraries before and during linked data implementation?

A qualitative case study approach provided an in-depth analysis of a few settings. To answer the research questions comprehensively, the authors used multiple data collection methods techniques and analysed them using constant comparative analysis. Constant comparative analysis

can be used on disparate resources, and it consists of comparing each piece of data with those that are similar or different, formulating concepts on the possible relationships among data, and building categories using the data (Pickard, 2007; Onwuegbuzie *et al.*, 2012). The incorporation of multiple data formats into a comparison process increases the rigor and reliability of the study's results because the data and their associated analysis methods provide different approaches to answering the research questions, and can be looked at separately as well as collectively. The analysis process involved three different phases of coding:

- Every set of information, after reading, was divided into smaller, meaningful parts, each of which was assigned with a descriptive label (open coding);
- Each new chunk of data was compared with previously determined codes, so that similar portions of data were assigned with the same labels (axial coding);
- Once all sets of information were labelled, codes were organised in bigger clusters by similarity, and themes were identified and described, based on each cluster (selective coding).

Initially, the authors conducted a literature review using LISA, LISTA, and Google Scholar, as well as materials that the first author had read before the study began, to investigate the status of linked data implementation and use across libraries, with a focus on European national libraries. Search logs, alerts, citation trails, and email lists afforded refinement of the searches to obtain the most appropriate results. Multiple formats included books, articles, conference proceedings, webinars, presentations, and online videos. Using a spreadsheet, the authors kept track of the references and eventually used it to code the main themes emerging from the literature with descriptive labels and associated colours using constant comparative analysis.

Next, one author held 15 semi-structured interviews with information professionals who work with LD or metadata in European national libraries. The literature review informed the interview topics, which included uses of LD across national libraries, reasons for implementing/not implementing LD, policies and technologies adopted, implementation processes, issues and benefits of implementation, best practices and future development. She located and recruited participants through the literature review, relevant websites, and social media. Choices for recruitment were made based on identifying authors of related published work and then contacting them via email or social media, emailing each European national library with a request to be put in touch with its metadata contacts, and following up with librarians mentioned in prior interviews. She conducted nine interviews over Skype and three via email. As with the literature review, constant comparative

analysis enabled coding of the interview transcriptions and the emails. The interview schedule (Appendix A) It was adapted according to the answers provided by participants during each interview. Also, some questions were revised after the first few interviews, following comments, suggestions, and responses from participants.

Next, to gain a more comprehensive look at European national libraries, an online resources analysis (n=26) looked at LD implementations of institutions that did not participate in an interview (Hewson, 2008). This allowed the authors to examine primary data gathered from the libraries' web presences, such as LD-enabled catalogues and individual records, weblog posts, policies, projects, and collections details. Browser extensions able to recognize SW structures such as Semantic Radar identified whether these libraries had implemented LD. In some cases, analysis included open datasets available through the country's government website. Additionally, the literature review provided information for the remaining European national libraries (n=5) that could not be either analysed online or interviewed. Combining the 26 online resources analysis, the 15 interviews, and the five discussed in the literature, the authors included all 49 European national libraries.

Simultaneously, one author distributed an online survey to public, academic, school and national librarians in Scotland (n=113) to analyse the awareness, perceptions and adoption of library LD in the country. Recruitment involved sharing a link to the survey on social media as well as on relevant Scottish information professionals' email lists. The survey appears in Appendix B. She initially analysed responses through simple descriptive statistics for the closed-ended responses and textual analysis for the open-ended responses. The authors ultimately incorporated these results into the larger study's constant comparative analysis.

Results

Tables 1 and 2 summarize results from the European national libraries, indicating the main channels through which data was collected for each one.

Table 1: Overview of research findings – Participating National Libraries

Table 2: Overview of research findings – Non-participating National Libraries

Examining online resources delivered the following highlights:

- Indications of the work towards LD implementation undertaken by the Swiss National Library were found through the opendata.swiss portal

(www.opendata.swiss, 2017), which uncovered a paper by Bättig and Schwery (2016) describing the method adopted by the institution to convert MARC21 records into RDF.

- Semantic Radar allowed the identification of RDF structures on the website of the National Library of Ukraine, which offers a 'Scientific search for publications in WEB 3.0' option (http://www.nbuv.gov.ua/node/1539/).
- SW elements were detected through Semantic Radar on the website of the Digital Library of the National Parliamentary Library of Georgia (http://dspace.nplg.gov.ge/?locale=en).

Linked data uses

Scottish and European national libraries have implemented LD for multiple uses and in various forms. In Scotland, a few libraries (7%; n=8) have adopted LD applications within MARC records, digitized resources, social media and research outputs using RDF, Dublin Core, and SPARQL. Plans to implement in Scotland (11%; n=12) involve OWL, SKOS, and the Europeana Data Model. European national libraries have chosen many paths in their quest to support SW development. The following sub-sections provide an overview of the most common ways.

Contributing to the LOD cloud

Several institutions, including those unable to implement LD alone, have decided to provide their data to datasets as follows:

- *VIAF*: BL, Czech Republic, Estonia, France, Germany, Hungary, Iceland, Ireland, Latvia, Luxembourg, Netherlands, Norway, Poland, Portugal, Russia, Scotland, Spain, Sweden, Switzerland, Vatican City, Wales
- *Europeana*: Austria, Croatia, Finland, France, Greece, Iceland, Latvia, Luxembourg, Norway, Poland, Romania, Scotland, Serbia, Switzerland, Ukraine

Although sharing data with such resources does not imply an active involvement with LD principles and technical requirements, it is a way of taking part in the LOD cloud, as the National Library of Latvia stated. Furthermore, Latvia attributes to Europeana the potential of incentivizing LD adoption across cultural heritage institutions because it could encourage organizations to integrate their data within the LOD cloud as RDF, rather than storing data in potentially non-interoperable formats.

Bibliographic and authority data

LD is most frequently adopted by national libraries to publish their bibliographic and authority data. These include the following:

- BnF (France) (http://data.bnf.fr/);
- BNE (Spain), (http://datos.bne.es/inicio.html);
- DNB (Germany) (*Gemeinsame Normdatei* = Integrated Authority File);
- National Library of the Netherlands;
- Open Knowledge Greece;
- Hungarian National Library (NektarWiki, 2011);
- Swedish National Library (LIBRIS, the Swedish Union Catalogue, http://libris.kb.se/);
- Ireland has created Linked Logainm (https://www.logainm.ie/en/inf/proj-machines), a LD version of the bilingual Irish place name database www.logainm.ie (Grant *et al.*, 2013).

National bibliographies

Publishing the national bibliography is a prime responsibility of a national library. The Finnish (*Fennica,* http://linkeddata-kk.lib.helsinki.fi/) and Swedish NLs have published their national bibliographies as LD, whilst Netherlands and Germany are working towards it. Britain deemed it more practical to release the British National Bibliography (BNB, http://bnb.bl.uk/#) as LOD rather than its whole catalogue, because it is authoritative, more consistent, and better maintained than its catalogue.

Digital resources

France, Hungary, Latvia and the Netherlands have adopted LD for their digital resources. The linked digital collection *Rainis and Aspazija* (http://runa.lnb.lv) is a recent development in Latvia. It is a pilot project testing how to enrich a digital collection with additional links between objects by annotating named entity references and exposing this information as LD.

Netherlands is currently involved in a national collaborative programme for digital heritage. It aims to build a LD national cultural heritage discovery infrastructure.

Thesauri and ontologies

Finland (*Finto,* https://finto.fi/en/), Germany (GND Ontology), Italy (*Nuovo Soggettario* = New Subject Heading, http://thes.bncf.firenze.sbn.it/ricerca.php) and Netherlands have published thesauri and ontologies as LD.

RQ1 - What are librarians' understandings of the concepts "linked data" and "Semantic Web"?

OCLC surveys conducted in 2014 and in 2015 investigating LD implementation amongst libraries worldwide identified difficulty in understanding SW concepts by staff as a key obstacle hindering LD adoption (Smith-Yoshimura, 2015). The national libraries taking part in this study denounced a lack of awareness of SW and LD principles among library staff. LD implementation is typically a side project involving a few individuals without wide institutional involvement.

Librarians are largely uncertain about the terms SW and LD.The Scottish survey showed that only 13% (n=15) of the participants declared confidence in their understanding of LD; 15% (n=17) were completely unaware of it. Only 8% (n=9) knew what SW means, while 37% (n=42) did not. Concepts participants suggested when asked to define LD included "data/resource sharing", "linking", "availability", and "connectedness". One participant stated, "I understand that this is a current term referring to an approach to publishing and sharing data on the Web, although I don't know much about it. As it suggests improved understanding and accessibility, I'm all for it!" Participants were much less certain when describing SW; emerging concepts included improved web searching and more structured online data for better organization.

RQ2 - What are the reasons behind libraries' decisions to implement linked data?

The research highlighted overlaps between reasons of implementation and perceived benefits of LD adoption: most European institutions have chosen to embrace the SW encouraged by its proven and supposed advantages. Nonetheless, further motivations pushing towards implementation relate to the fact that LD and SW have been under the spotlight for a while in the sector. Participants identified curiosity and growing awareness of its need as incentives towards development. Furthermore, some national libraries have chosen to experiment with LD because others are doing it; this was viewed as proof that it deserves time and resources.

In a few cases, the decision to implement LD came from the adherence to established open government data policies. That was the case for the British Library and for the National Library of Scotland. Although it has not achieved LD implementation, NLS has embraced open data in order to comply with its government's open data strategy (National Library of Scotland, 2017).

France and Wales stated that LD was chosen as the best fit for their purposes and the most appropriate way of publishing their data. Netherlands' main reason was integration: to combine their bibliographic records with other resources.

RQ3 - What are the perceived benefits of library linked data implementation?

Augmenting Web data visibility and discoverability was amongst the most popular advantages assigned to LD, as in France, Spain, Portugal, Germany, Netherlands and Italy. In order to obtain better discoverability of their data through search engines, some national libraries have adopted Schema.org. Born from the collaborative efforts of Bing, Google, and Yahoo! with the aim of improving relevance rates, Schema.org is a standard for marking up pages with semantic data (Neish, 2015).

Data enrichment/quality enhancement was the reason for Luxembourg, Portugal, Germany and Netherlands. Data enrichment is enabled by establishing links to external resources, as well as by the intensive preparation required for LD implementation. Wales, Britain and Netherlands mentioned improving usability of existing datasets. LD offers the means to make existing data available in a new way, such as in Britain, which chose LD to enhance the long-established BNB.

Sweden, Germany, Britain and France stated that LD's added value consists of opening up data silos and making data reusable for a wide range of purposes and to communities beyond the library environment. Netherlands defines publishing LD as a form of "social contract": each organization is responsible for the data provided and is invested with the task of ensuring that data stays available in a persistent way that does not disrupt user experience. LD requires deep reflection on the quality and uses of existing data.

Sweden has identified several benefits. The disambiguation ability, derived from the fact that each element is uniquely identified, supports multilingualism. Furthermore, LD provides tools to reduce cataloguers' workload, since it enables libraries to reuse information already available elsewhere (Library of Congress, 2012b).

RQ4 - What are the barriers to linked data adoption?

Participants indicated major barriers hindering LD implementation, even when government directives for open data exist. Lack of knowledge and expertise figures at the top of the list: Scottish libraries and European national libraries denounced a lack of awareness of SW and LD principles amongst staff and lack of technical skills necessary for adopting LD. This is

particularly true for early implementers, such as Britain and France, which could not utilize many existing examples. Although LD implementations keep increasing and several tools have been designed to support the process, lack of resources, lack of staff and lack of time still represent primary obstacles for institutions interested in adopting LD. These barriers are intertwined, as shown in Figure 2.

Figure 2: Intertwined barriers to library linked data implementation

When implemented, a limited task force develops it, since it is not prioritised within the library's overall mission and strategy. Some participants reported the struggle of obtaining management buy-in for project approval. As Latvia suggests, high-level management must see tangible proof of LD's benefits to justify the validity of the substantial investment required.

LD implementation causes staff disruption and changing workflows. Some participants lamented that librarians attempt to maintain and improve current systems rather than opting for a major change. This is particularly true for LD, as its implementation raises new concerns such as licencing constraints. Britain and Netherlands affirm that LD "makes sense" only if published as LOD, under a CC0 licence. However, this makes it impossible to track who is using the data and what it is used for. This leads to losing control over their data on one hand and being unable to measure usability, usefulness and uptake of LD on the other hand. Britain has

found a partial solution to this problem through its collaboration with Fujitsu International, which developed tools to obtain a clearer picture of their users.

Scottish librarians expressed concerns related to the profession being at stake. Perceived risks such as commercialization and losing control of library data discourage the idea of opening data.

RQ5 - What are the challenges encountered by libraries before and during linked data implementation?

Participants identified many implementation challenges. Lack of guidelines and step-by-step instructions to guide implementation as well as a scarcity of adequate tools and infrastructure to support LD were difficulties for early implementers.

For some national libraries, the fact that LD can be published in several different ways has created difficulties for determining how to present data in the most useful way. Lack of uniform standards to transform data into RDF (and then LD) has resulted in complex conversion processes for a few institutions. Furthermore, most respondents faced a difficult choice of adopting existing ontologies or creating new ones that better fit their data.

LD requires elaborate data processing, as well as an intensive effort in maintaining data quality over time with regular and efficient updates. One of the most demanding phases of LD implementation for some participants was the formulation and attribution of URIs, alongside with guaranteeing future persistency.

Discussion and recommendations

Many participants cited collaboration as the solution to widening libraries' SW participation. By merging efforts and sharing knowledge, they could create more sophisticated methods to overcome technical issues as well as provide guidance to new implementers. Several respondents stressed the importance of conferences as collaborative learning opportunities (e.g., Semantic Web in Bibliotheken, http://swib.org/). Germany expressed a strong need for forums to discuss issues and find solutions. Partnership and cooperation represent the only way to participate in SW advancement for libraries lacking resources to implement LD fully, as Luxembourg and Portugal stated.

The lack of awareness and technical skills denounces a strong need for promoting training across library staff (Byrne and Goddard, 2010). Considering the high costs of training,

collaboration between institutions is essential. Nevertheless, spreading awareness of what library LD is and why it is important should be prioritized.

It is time to give library collections the chance to be made available to the world; in this context, awareness and advocacy are closely related. Proof of successful LD implementations, such as Google, Facebook, and major libraries, can build a case for support. Google is considered an enemy of the (traditional) information profession, but librarians can learn new tricks from their antagonist.

It should be noted that the results in this study are indicative rather than comprehensive. This limitation stems from the fact that not all libraries replied to interview invitations, and not all libraries' linked data status could be located in the literature review. In these cases, the online resources analysis stood in for covering the library by Semantic Radar on a few pages within the libraries' websites, such as OPACs and collections pages, but it is possible that linked data information appeared on other pages. Additionally, despite the use of Google Translate, language barriers may have affected the research, and website navigation was difficult on some websites.

Best practice

Some Scottish librarians expressed interest in learning more about LD. In order to respond to this need and to assist libraries considering implementation, the authors collected recommendations from those institutions who have experience with it:

- Make use cases and carefully evaluate if LD is the right technology for your scope
- Start working with LD, even on something small
- Take advantage of the increasing resources available to support implementation
- Look at examples of successful projects
- Get in touch with LD implementers, through conferences or other means, to learn best practices
- Seek expert developers to carry out the implementation outside the institution, if necessary
- Focus on data specific to your institution (e.g. national bibliographies for national libraries)
- Have a community of stakeholders wider than just the library community

- Consider URI syntax: reflect on how you want to identify your data and keep it available permanently
- Reuse data, whenever possible (e.g. reuse national authority files, if already published elsewhere)
- Collaborate with local universities and benefit from their expertise in matters such as ontology modelling
- Count on professionals who understand both the technical and the content sides
- Adopt an entity-based approach to data
- Design a careful roadmap and a detailed strategy before acting
- Use existing vocabularies whenever possible

Further recommendations, gathered by the OCLC surveys previously mentioned, include:

- Focus on goals, rather than technical matters
- Pick a problem you can solve
- Consider legal issues from the start
- Understand LD structure, available ontologies, and your own data
- Strive for long-term data reconciliation and consolidation
- Involve your institution/community (Smith-Yoshimura, 2015)

Although an international standard, LD implementation has been an uneven and gradual process across libraries and currently still in early stages (Frederick, 2017). As Netherlands stated, starting LD implementations would benefit from governmental mandates, rather than originating from the discretion of individual institutions. Recognizing the need for LD at the national level, thus elaborating a strategy to be followed by all cultural heritage institutions, would represent a powerful incentive to SW development. In this sense, the cases of Britain and Scotland adhering to governmental policies are emblematic. This study highlighted that Scottish libraries still consider LD a niche technology, as do European national libraries. Promoting awareness of SW's potential is a key priority in order to create wider adoption. Conferences, email lists and forums are ways to stay up-to-date with the latest developments as well as useful sources for advice. If opening data becomes a government-mandated practice, then priorities must be revised and resources must be allocated towards this goal.

Further research

Several remaining issues require further research. First of all, it is essential for libraries to agree on a universal model, in order to reduce the complexity of data integration (Svensson, 2013).

At present, there is no one model used for all library data. Cooperation between cultural institutions, the information environment and data consumers, is essential to identify a common pattern (Svensson, 2013). Libraries may miss the opportunity of taking advantage of LD if they fail to find a standard implementation path, with the result of moving from the problem of 'MARC silos' to the issue of 'LD silos' (Suominen and Hyvönen, 2017). The tool for overcoming this must involve an integrated strategy guiding the design of seamless and inclusive discovery systems (Shiri and Davoodi, 2016).

A further issue relates to ontologies. Greece mentioned how years after the first LD project was realized, a specific ontology to describe library data has not yet been designed. LD implementers are still faced with the dilemma of reusing ontologies or developing new ones. Furthermore, solutions must be sought towards automating the linking process, which is time-consuming if carried out manually (van Hoolan and Verborgh, 2014). The way to achieve improvement in these technical matters is to improve dialogue and collaboration between libraries, developers, and vendors. Librarians must clearly express their needs so that vendors can design satisfactory products.

While discussion has mainly focused on using LD for representing bibliographic and authority data, the exploration of new applications is needed. For example, how might libraries' digitized cultural heritage objects themselves be linked and shared?

Conclusions

This is the first known study to present a multinational comprehensive picture of library LD implementations and associated librarians' perceptions. Despite the achievements of several European national libraries, LD is still considered a niche technology. A minority of participating institutions (n=15 national libraries; n=8 Scottish libraries) have applied LD to their resources. Each library has developed LD in isolation, which has resulted in different technical implementations, uses, and tools. A lack of human resources, finances, expertise, and implementation guidelines emerged among the primary obstacles. Several institutions stated that presenting LD as the future of library data management was the trigger to begin experimentation. A few libraries demonstrated the advantages of augmenting data visibility and discoverability, supporting interoperability and data reuse within and beyond the library environment, and overcoming obstacles such as linguistic barriers. However, some institutions expressed disappointment in implementation and its results, as well as reservations about presenting the truthfulness of LD's vision to users.

Libraries' potential role in improving SW access should be seen as a natural evolution of facilitating access to the Web of documents; the SW is simply an outcome of the latest technical developments (Stuart, 2011). The authors make a drastic suggestion: libraries' failure to embrace the Web of Data will lead to the end of librarianship.

With LD, libraries can assume leadership as providers of seamless access to information sources, not only for their own users, but also for the wider web community (Shiri and Davoodi, 2016). Nevertheless, libraries are a long way from taking full advantage of LD's potential. The obstacles identified in this study demand better cooperation amongst libraries, system developers/vendors and users so that collective efforts can be effective in finding appropriate solutions tailored to users' needs. As the case of Scotland demonstrated, not even government-mandated open data policies automatically translate into immediate open data publication. Governments need to nurture a culture in which opening data to the public is a standard procedure. Legal and political requirements may be the only way for some cultural institutions to obtain management approval of LD implementation projects. Concrete demonstrations of LD's potential can play a primary role in supporting the SW's advancement; circulating successful use cases can both spread awareness of LD and provide tangible proof for management buy-in. Collaboration among institutions is key to enable further SW development.

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Appendix A: Interview schedule for European national libraries

1. Have you implemented LD in any of your library resources?

If 'no':

2. Could you explain your organisation's concerns/reserves preventing you from opting for an implementation of LD? Extra: 2.1. What barriers were identified that discouraged or impeded the adoption of this technology?

3. Have you reflected on benefits that LD could bring to your institution?

4. What impact, if any, could the examples offered by successful projects accomplished by other institutions have on your future choices? Extra: 4.1. Have you identified any application of LD that, in your opinion, has proved particularly successful and beneficial to library resources? Probing: 4.2. Can you provide examples?

5. Have you ever reflected on the role that the adoption of agreed standards plays with respect to creating uniform systems and allowing interoperability among datasets? Extra: 5.1.

Have you ever considered what the relationship between LD spread and further development and standardisation is?

6. Is there any plan in place at your institution for a future change of direction? Probing: 6.1. Can you provide more details?

7. Would you like to add any further comment/reflection? Extra: your thoughts on future development on LD within the information and library sector or in general? - End of interview

If 'yes':

1.1 What were the reasons behind your choice of implementing LD?

2. Have you identified the key barriers that delayed or could potentially have prevented LD implementation at your institution? Probing: 2.1. Can you provide more details on this?

3. Can you describe the main features of the project realised? Extra: 3.1. What were the main steps taken? 3.2. How much of the process could benefit of automated or ready-to-use technologies?

4. What example have you looked at, if any? Extra: 4.1. Do you reckon a particularly successful project within the information sector has proved the usefulness of LD? 4.2. How about projects beyond the Information & Library sector?

5. What is the policy adopted at your institution with respect to LD implementation and use, if any?

6. Have you ever reflected on the impact that the adoption of agreed standards has with regards to creating uniform systems and allowing interoperability among various datasets? Extra: 6.1. What would you say is the relationship between LD spread and further development and the adoption of standards?

7. Has collaboration with other institutions helped the actuation of your project? How do you believe it could support the development of LD within the information and library context? Extra: 7.1. How do you believe collaboration between cultural institutions could support the development of LD?

8. What were the foreseen benefits of implementing LD? Did reality meet the expected outcomes? Extra: 8.1. What were your expectations prior to starting the implementation? 8.2. What do you think went well?

9. How about the challenges? Foreseen and actually encountered ones? Extra: 9.1. Have experienced issues related to training, implementation cost, time management, resources required/involved in the process? 9.2. What would you say went wrong?

10. Would you like to add any further comment/reflection? Extra: 10.1. Do you have any suggestions that you would like to pass to institutions who are looking into implementing LD or reflections on future LD development within the ILS sector?

Appendix B: Online survey: Linked data in Scottish libraries

Do you know what the term "linked data" means?

Definitely yes

Probably yes

Might or might not

Probably not

Definitely not

In your own words, describe what the term "linked data" means to you.

Do you know what the term "Semantic Web" means?

Definitely yes

Probably yes

Might or might not

Probably not

Definitely not

In your own words, describe what the term "Semantic Web" means to you.

Has your library implemented, or is it planning to implement, any linked data applications on its online resources?

We have implemented linked data applications.

We have plans to implement linked data applications.

We have no current plans to implement linked data applications.

If no current plans, display this question:

Why do you not have plans to implement linked data applications? Please choose all that apply.

We do not know what it is.

We do not have adequate technical resources.

We do not have appropriate staff.

We do not see a need for it.

We do not have enough online resources to make linked data useful.

Other (please specify):

If plans to implement, display this question:

Which of your library's online assets do you plan to include in your future linked data applications? Please select all that apply.

MARC records in our catalogue

Digitised resources (photographs, maps, historical records, etc.)

Static library web pages

Library blogs or other social media

Other (please specify):

If plans to implement, display this question:

Which of the following do you plan to use in the implementation of your linked data applications? Please select all that apply.

Resource Description Framework (RDF)

Simple Knowledge Organisation System (SKOS)

Web Ontology Language (OWL)

SPARQL

Dublin Core (DC)

Virtual International Authority File (VIAF)

DBPedia

Don't know/not sure

Other (please specify)

If plans to implement, display this question:

Please provide more detail about your linked data application plans (optional):

If implemented, display this question:

Which of your library's online assets have been included in your linked data applications? Please select all that apply.

MARC records in our catalogue

Digitised resources (photographs, maps, historical records, etc.)

Static library web pages

Library blogs or other social media

Don't know/not sure

Other (please specify):

If implemented, display this question:

Which of the following have been used in the implementation of your linked data applications? Please select all that apply.

Resource Description Framework (RDF)

Simple Knowledge Organisation System (SKOS)

Web Ontology Language (OWL)

SPARQL

Dublin Core (DC)

Virtual International Authority File (VIAF)

DBPedia

Don't know/not sure

Other (please specify)

If implemented, display this question:

Please provide more detail about your linked data applications (optional):

In what type of library do you work?

Public

Academic

National

School

Other (please specify)

What is your job title?

If there is anything else you would like to share about linked data in Scottish libraries, please add it here.

Table 1: Overview of research findings – Participating National Libraries

Participating National Libraries			
	Implemented	**Intending to implement**	**Not implemented**
Skype	Finland Germany Greece (Open Knowledge Greece) Latvia The Netherlands United Kingdom (British Library) Wales	Luxembourg Portugal	
Email	France Spain	Italy	Bulgaria Czech Republic Liechtenstein

Table 2: Overview of research findings – Non-participating National Libraries

Non-participating National Libraries			
	Implemented	**Not implemented**	**Taking steps towards Semantic Web**
Literature review	Hungary Ireland Sweden		Austria Poland
Web resources analysis	Georgia Switzerland Ukraine	Albania (www.bksh.al) Armenia (www.nla.am) Azerbaijan (anl.az/new) Belarus (www.nlb.by) Belgium (www.kbr.be) Bosnia and Herzegovina (www.nub.ba) Croatia (www.nsk.hr) Cyprus (www.cypruslibrary.gov.cy) Denmark (www.kb.dk) Estonia (www.nlib.ee) Iceland (landsbokasafn.is) Kosovo (www.biblioteka-ks.org/#) Lithuania (www.lnb.lt) Macedonia (nubsk.edu.mk) Malta (www.maltalibraries.gov.mt) Moldova (www.bnrm.md) Montenegro (nb-cg.me) Norway (www.nb.no) Romania (www.bibnat.ro) Russia(www.nlr.ru) San Marino (www.bibliotecadistato.sm) Serbia (www.nb.rs) Slovakia (www.snk.sk) Slovenia (www.nuk.uni-lj.si) Turkey (www.mkutup.gov.tr)	

		Vatican City (www.vatlib.it)	